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Example

- A is a set of all positive integers less than 10,
 A={1, 2, 3, 4, 5, 6, 7, 8, 9}
- B is a set of first 5 positive odd integers, B={1, 3, 5, 7, 9}
- C is a set of vowels, C={a, e, i, o, u}

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Defining Sets

- This can be done by:
 - Listing ALL elements of the set within braces.
 - Listing enough elements to show the pattern then an ellipsis.
 - Use set builder notation to define "rules" for determining membership in the set.

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Example

- 1. Listing ALL elements. $A = \{1, 2, 3, 4\}$ explicitly
- 2. Demonstrating a pattern. $\mathbb{N} = \{1, 2, 3, \ldots\}$ implicitly
- 3. Using set builder notation. $P = \{x \mid x \in \mathbb{R} \text{ and } x \notin \mathbb{C}\}$

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Sets

- A set is determined by its elements and not by any particular order in which the element might be listed.
- Example,

 $A=\{1, 2, 3, 4\},\$

A might just as well be specified as

{2, 3, 4, 1} or {4, 1, 3, 2}

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Sets

- The elements making up a set are assumed to be distinct, we may have duplicates in our list, only one occurrence of each element is in the set.
- Example

$$\{a, b, c, a, c\} \longrightarrow \{a, b, c\}$$

 $\{1, 3, 3, 5, 1\} \longrightarrow \{1, 3, 5\}$

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Sets

- Use uppercase letters A, B, C ... to denote sets, lowercase denote the elements of set
- The symbol ∈ stands for 'belongs to'
- The symbol ∉ stands for 'does not belong to'

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Example

- $X=\{a, b, c, d, e\}, b \in X \text{ and } m \notin X$
- $A=\{\{1\}, \{2\}, 3, 4\}, \{2\}\in A \text{ and } 1\notin A$

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Sets

- If a set is a large finite set or an infinite set, we can describe it by listing a property necessary for memberships
- Let *S* be a set, the notation,

 $A = \{x \mid x \in S, P(x)\}\ \text{or}\ A = \{x \in S \mid P(x)\}\$

means that A is the set of all elements x of S such that x satisfies the property P.

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Example

Let A={1, 2, 3, 4, 5, 6}, we can also write A as,

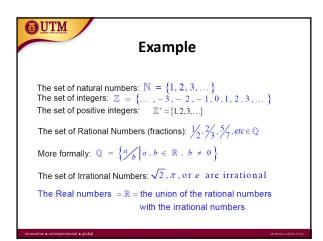
 $A=\{x \mid x \in Z, 0 < x < 7\}$

if Z denotes the set of integers.

• Let $B=\{x \mid x \in \mathbb{Z}, x>0\}, B=\{1, 2, 3, 4, ...\}$

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OUTM Some Symbols Used With Set Builder Notation The standard form of notation for this is called "set builder notation". For instance, $\{x \mid x \text{ is an odd positive integer}\}\$ represents the set $\{1, 3, 5, 7, 9, ...\}$ $\{x | x \text{ is an odd positive integer} \}$ is read as "the set consisting of all x such that x is an odd positive integer". The vertical bar, " | ", stands for "such that" Other "short-hand" notation used in working with sets "∀" stands for "for every" "3" stands for "there exists" "U" stands for "union" "\" stands for "intersection" "⊆" stands for "is a subset of" "⊂" stands for "is a (proper) subset of" "⊄" stands for "is a not a (proper) subset of" "Ø" stands for the "empty set" "∈" stands for "is an element of" "∉" stands for "is not an element of" "x" stands for "cartesian cross product" "=" stands for "is equal to"

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Subset

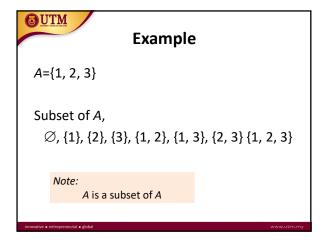
• If every element of A is an element of B, we say that A is a subset of B and write $A \subseteq B$.

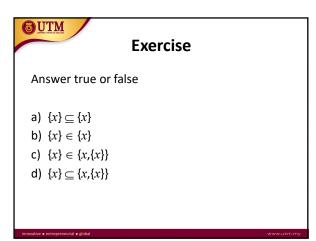
A=B, if $A \subseteq B$ and $B \subseteq A$

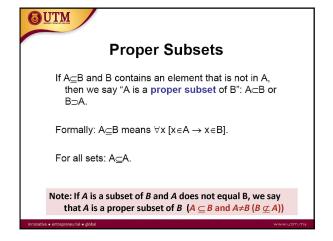
• The empty set (∅) is a subset of every set.

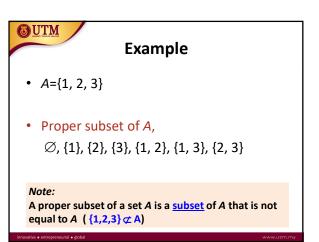
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Example

Let a set, $B=\{1, 2, 3, 4, 5, 6\}$ and the subset, $A=\{1, 2, 3\}$.

 \Rightarrow A is proper subset of B.

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Example

A={a,b,c,d,e,f,g,h}

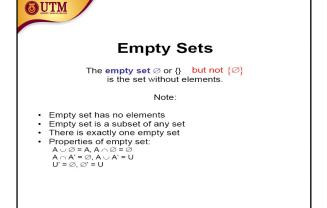
B={b,d,e}

C={a,b,c,d,e}

D={r,s,d,e}

• Proper subset of A?? B and C

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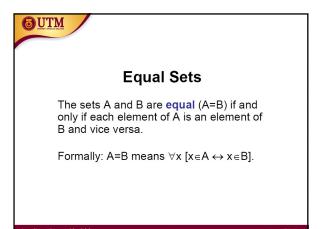
Example

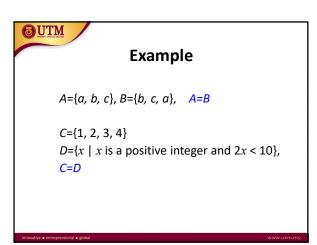
 \emptyset = { $x \mid x$ is a real number and $x^2 = -3$ }

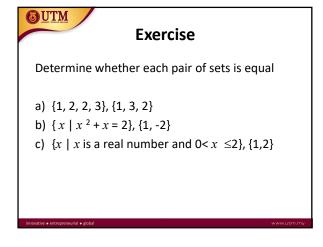
 \emptyset = { $x \mid x$ is positive integer and $x^3 < 0$ }

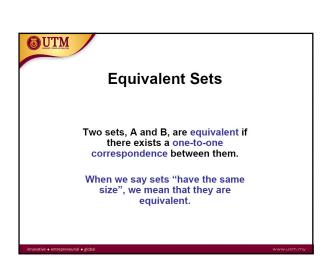
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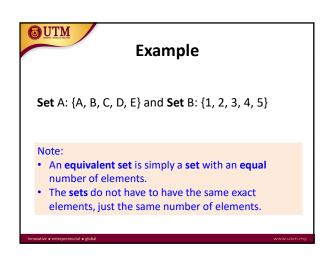
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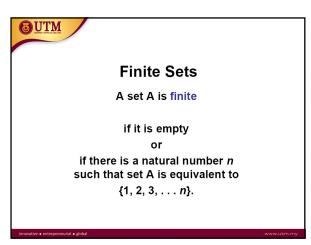


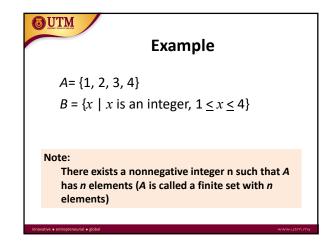


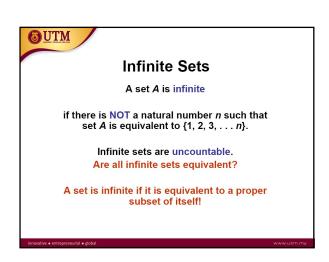












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Example

 $Z = \{x \mid x \text{ is an integer}\}\$ or $Z = \{..., -3, -2, -1, 0, 1, 2, 3,...\}$

 $S=\{x \mid x \text{ is a real number and } 1 \le x \le 4\}$

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Example

 $C = \{5, 6, 7, 8, 9, 10\}$ (finite set)

 $B = \{x \mid x \text{ is an integer, } 10 < x < 20\}$ (finite set)

 $D = \{x \mid x \text{ is an integer, } x > 0\}$ (infinite set)

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Universal Set

- Sometimes we are dealing with sets all of which are subsets of a set *U*.
- This set *U* is called a universal set or a universe.
- The set *U* must be explicitly given or inferred from the context.

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Universal Set

Typically we consider a set A a part of a **universal set** \mathcal{U} , which consists of all possible elements. To be entirely correct we should say $\forall x \in \mathcal{U} [x \in A \leftrightarrow x \in B]$ instead of $\forall x [x \in A \leftrightarrow x \in B]$ for A=B.

Note that { x | 0<x<5} is can be ambiguous. Compare { x | 0<x<5, x \in N } with { x | 0<x<5, x \in Q }

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Example

- The sets A={1,2,3}, B={2,4,6,8} and C={5,7}
- One may choose *U*={1,2,3,4,5,6,7,8} as a universal set.
- Any superset of *U* can also be considered a universal set for these sets *A*, *B*, and *C*.
 For example, *U*={x | x is a positive integer}

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Cardinality of Set

- Let *S* be a finite set with *n* distinct elements, where $n \ge 0$.
- Then we write |S|=n and say that the cardinality (or the number of elements) of S is n.
- Example

 $A = \{1, 2, 3\}, |A| = 3$ $B = \{a, b, c, d, e, f, g\}, |B| = 7$

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Exercise

- If *M* is finite, determine the |*M*|
 - $\text{ If } M = \{1, 2, 3, 4\}$
 - $\text{ If } \mathbf{M} = \{4, 4, 4\}$
 - $\text{ If } M = \{\}$
 - If $M = \{\emptyset, \{\emptyset\}, \{\emptyset, \{\emptyset\}\}\}\$

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Power Set

The set of all subsets of a set A, denoted
 P(A), is called the power set of A.

$$P(A) = \{X \mid X \subseteq A\}$$

• If |A|=n, then $|P(A)|=2^n$

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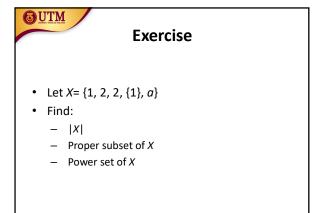
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Example

- *A*={1,2,3}
- The power set of A,
 P(A)= {Ø, {1}, {2}, {3}, {1,2}, {1,3}, {2,3}, {1,2,3} }
- Notice that |A| = 3, and $|P(A)| = 2^3 = 8$

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Exercise

• List the member of $P(\{a, b, c, d\})$. Which are proper subset of $\{a, b, c, d\}$?

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